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OCCURRENCE OF EPIZOIC COMMUNITIES ON THE PARASITIC COPEPOD *LERNAEA CARASSII* (LERNAEIDAE)

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Whereas epiphytic organisms (organisms living attached to the external surface of plants) are commonplace in both terrestrial and aquatic environments, epizoic organisms (nonparasitic organisms living attached to the surface of animals) are less common. Sessile freshwater and marine organisms frequently harbor rich periphyton growth on their hard outer body surfaces (i.e., barnacles and certain molluscs of the pelecypoda, gastropoda, and amphineura). Slow-moving aquatic animals, such as decapod crustaceans and turtles, are known to support rich epizoic flora and fauna. The terrestrial neotropical sloth, *Bradypus variegatus,* supports a number of arthropod species within its fur. In addition to several beetle and mite species, the life cycle of the moth *Cryptoses cholopei* was found to be closely associated with the behavior of sloths (Waage and Montgomery, 1976; Waage and Best, 1985). The associations between sharksuckers (*Echeneis* and *Remora*) and large marine fishes and mammals are well known, as is occurrence of barnacles on marine cetaceans. To our knowledge, occurrences of epizoic plant assemblages in association with fishes have not been described. We report observations of an association among mosquitofish, *Gambusia affinis* Baird and Girard, the parasitic copepod *Lernaea carassii* Tidd, and a rich epizoic assemblage of periphyton and associated animals.

Gambusia affinis were collected by dipnet from ponds on the University of Texas, Austin, campus on 16 and 24 December 1986 and 1 and 4 January 1987. The ponds averaged about 60 cm in depth, substrate consisted of fine organic sediments, water temperature was 12.5°C (14 January 1987, 1730 h), and dissolved oxygen was 8.0 ppm. In addition to *G. affinis,* ponds contained water hyacinths (*Eichhornia crassipes*), lilies (*Nymphaea* sp.), goldfish (*Carassius auratus*), and red-eared turtles (*Pseudemys scripta*). Immediately following collection, fishes were preserved in 10% formalin solution. Specimens were subsequently counted, measured (standard length, SL), and examined for infestations of the parasitic copepod *Lernaea carassii* (two fishes were returned to the lab and photographed live prior to preservation).

After its position on the fish's body was recorded, parasitic copepods were removed with dissecting needles and fine watchmaker's forceps under a dissecting microscope. Copepods were measured (nearest 0.1 mm) from the anchor to the anterior margin of the cephalothoracic carapace. Epizoic flora and fauna were examined under a bright field, Nikon compound microscope at 100× and 1,500×. Diatoms were observed prior to and after cleaning with H_2O_2 and $K_2Cr_2O_7$ to oxidize organic material. Taxonomy was done with an Olympus, bright field microscope at 1,500×. The primary references for identification were Patrick and Reimer (1966, 1975).

Twenty-two of 634 (3.5%) mosquitofish collected were parasitized by *L. carassii.* Copepods were found on virtually all portions of the fishes' bodies but most frequently on the caudal peduncle or dorsal, midbody region. On all but the smallest copepods, the presence of an extensive epizoic community was indicated by a fuzzy, golden brown or green mass (Fig. 1). In several instances, the entire exposed surface of the copepod was blanketed by a mass several millimeters thick. Examination of the epizoic flora and fauna on the carapace of *Lernaea* revealed a total of 37 species of diatoms (Table 1). The tube-dwelling *Nitzschia filiformis* and the stalked *Gomphonema subclavatum, Gomphonema parvulum,* and *Gomphonema olivaceum* were the dominant species of diatoms in terms of abundance and number of copepods invaded. The common stalked diatoms were attached directly to the copepod carapace and provided substrate for the attachment of other diatoms, such as *Cymbella* sp., *Navicula* sp., and

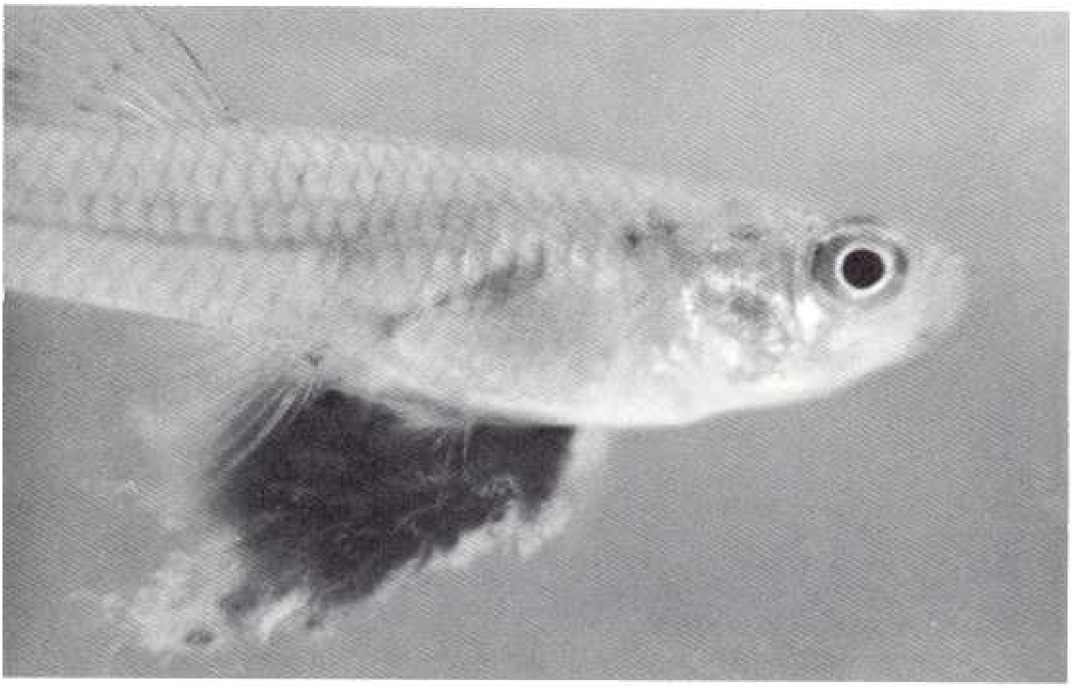

FIG. 1—Photograph of *Gambusia affinis* (25.0 mm standard length) parasitized by *Lernaea carassii* supporting a rich periphyton community.

Fragilaria brevistriata (Fig. 2). A minimum of three species of Myxophyceae, two species of Chlorophyceae, two species of Desmidiaceae, three species of protozoan, three species of rotifers, one species of Nematoda, and larvae of one species of chironomid (Diptera) were encountered among the epizoic periphyton assemblages.

There was no significant relationship between the number of epizoic diatoms or total epizoic species with standard length of mosquitofish (F-test, $P > 0.05$). However, a regression of the number of diatom species against copepod length showed nearly linear recruitment of diatoms with time (i.e., assuming a linear growth rate of copepods; Fig. 3A). The number of primary producer species, consumer species, and total number of epizoic species also showed patterns of successive floral and faunal build-up with copepod size (Fig. 3B, C). Linear regressions provided the best model for primary producer and consumer recruitment, whereas binomial equations best modelled diatom and total species recruitment (Fig. 3). Ciliated protozoa and nematodes were the first heterotroph colonizers occurring on *Lernaea* as small as 7.0 mm in length. In no case were heterotrophs present in the assemblage until at least 10, and usually more, species of diatoms had become established. Water mold was observed in seven cases but appeared to be associated with fish tissue damaged by the anchor of *Lernaea* rather than the copepod carapace.

Of the 29 species of diatoms for which we currently have ecological information (Table 1), one is limnophilous (characteristic of standing water), one is limnobiontic to limnophilous (characteristic of standing water but sometimes found in running water), two are limnobiontic to indifferent, and two are limnophilous to indifferent. That is, six species were characteristic of standing water or indifferent to current, and 23 species were either indifferent to current or characteristic of lotic environments. The movement of the fish apparently provides a running-water microenvironment within the lentic pond habitat, thus promoting the growth of many rheophilous and rheobiontic diatoms.

Diatoms were distributed spatially according to their method of attachment to the substrate.

FIG. 2—Microphotographs showing stalked diatoms (scale = 50 μm). Upper photo: *Gomphonema* dominated assemblages attached to copepod body. Lower photo: *Cymbella* assemblage anchored to *Nitzschia* tubes.

TABLE 1—List of diatom species, their frequencies of occurrence on *Lernaea carassii* (based on a total of 22 copepods), and their reported habitat affinities.

Species	No. of copepods epizoic	Habitat affinity[1]
Achnanthes exigua Grun.	2	
Achynanthes linearis (W. Sm.)	3	
Achnanthes minutissima Kutz.	3	
Amphora ovalis (Kutz.) Kutz.	5	
Amphora veneta Kutz.	3	
Anomoeoneis sphaerophora var. *sculpta* O. Mull	2	
Anomoeoneis vitrea (Grun.) Ross	2	
Bacillaria paradoxa Gmelin	4	
Cocconeis placentula Ehr.	5	
Cymbella cesatii (Rabh.)	4	
Cymbella cistula (Ehr.)	3	
Cymbella minuta Hilse ex Rabh.	1	
Cymbella tumida (Breb. ex Kutz.) V. H.	4	
Denticula elegans Kutz.	2	
Entomoneis sp.	1	
Fragilaria brevistriata var. *inflata* (Pant.) Hust.	12	
Fragilaria brevistriata var. *subcapitata* Grunow	1	
Gomphonema intricatum Kutz.	3	
Gomphonema olivaceum (Lyngb.) Kutz.	10	
Gomphonema parvulum (Kutz.)	16	
Gomphonema subclavatum (Grun.) Grun.	17	
Gomphonema truncatulum (Ehr.)	2	
Navicula biconica Patr.	1	
Navicula heufleri Grun.	7	
Navicula mutica Kutz.	1	
Navicula pygmaea Kutz.	2	
Navicula schroeteri var. *escambia* Patr.	10	
Navicula tripunctata (O. Mull.) Bory	3	
Nitzschia amphibia Grun.	12	
Nitzschia cf. *linearis* W. Smith		
Nitzschia cf. *filiformis* (W. Smith) Hust.	16	
Nitzschia cf. *palea* (Kutz.) W. Smith	6	
Nitzschia tropica Hust.	3	
Pinnularia acrosphaeria (Pant.) Ross	1	
Rhopalodia gibberula (Ehr.) O. Mull	1	
Synedra acus Kutz.	1	
Synedra rumpens Kutz.	1	
Synedra ulna (Nitz.) Ehr.	10	

[1] Habitat affinities were based on Round (1965), Patrick and Reimer (1966, 1975), and Lowe (1974).

Early colonizing species, such as *Cocconeis placentula,* tend to be adnate, attaching by a mucilage pad which anchors the entire face of the diatom valve. In this manner, early colonizing diatoms are able to withstand higher surface current velocities that occur in the absence of the baffling effect provided by more mature community structures. Forms with short stalked attachment pads at one end of the valve, such as *Achnanthes* sp., were extended short distances above the substrate and often produced fan-shaped colonies. Tube-dwelling diatoms and stalked forms, such as *Gomphonema* and some species of *Cymbella,* extending their living area above other diatoms. The tube-dwelling diatom *N.* cf. *filiformis* produced colonies that are many times longer than individual cells. Stalked forms were frequently attached to the sturdy tubes of colonies of *Nitzschia* (Fig. 2), fur-

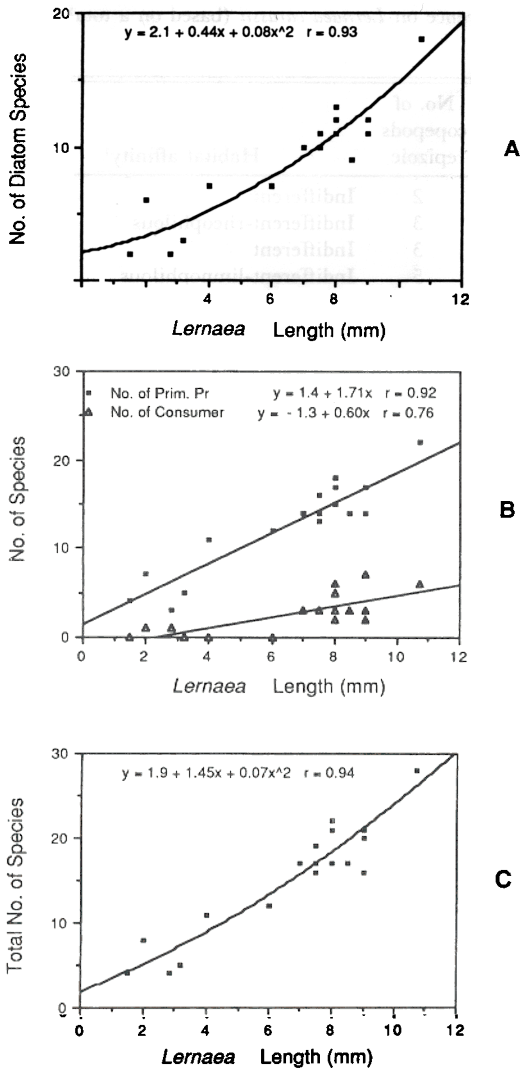

FIG. 3—Plots of the number of diatom species (A), primary producer (=prim pr) and consumer species (B), and total species (C) constituting the periphyton community on *Lernaea* of varying lengths. Regression equations represent the best-fit model

ther expanding the area of occupation and access to light, space, and nutrients several millimeters above the substrate. The protozoan *Vorticella* also used diatom tubes as a site for stalk attachment. Diatoms that produce gelatinous coatings attached and embedded themselves among the copious mucilage produced by the stalked and tube-dwelling forms. Motile diatoms (those possessing a raphe) were probably capable of gliding over the entire surface of the assemblage, further binding the mass.

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